A CASE OF EMPHYSEMATOUS GANGRENE OF THE HAND DUE TO THE STREPTOCOCCUS PYOGENES AND THE BACILLUS ÆROGENES CAPSULATUS: RECOVERY WITHOUT AMPUTATION.[1]

By ARTHUR HOWARD MANN, Jr., M.D.,

OF BALTIMORE,

ASSISTANT CHIEF OF CLINIC TO THE PROFESSOR OF SURGERY AND ASSISTANT DEMONSTRATOR OF ANATOMY IN THE UNIVERSITY OF MARYLAND.

Case.—William Richter presented himself the first time July 24, 1893, at the Dispensary of the University of Maryland with the following history and symptoms: Age, forty-seven years; native of Marburg, Germany; has been living in the United States since 1866; occupation, hydraulic engineer; gives a good family history, never had any specific disease: last sickness, twenty years ago, was typhoid fever.

He noticed a small black blister, on the palmar surface and near the end of the ring finger of the left hand, on the evening of July 14, 1893, which remained stationary for about one week, after which time his hand commenced to swell, got red and became very painful. He had a chill, which was followed by marked sweating, and severe pain, which extended over the hand and forearm, preventing the patient from sleeping the night before he presented himself for treatment.

Condition upon admission was as follows:

His third finger was very much swollen, red and very painful; the redness and swelling extending over the entire dorsal surface of the hand; he had a most marked lymphatic involvement of the arm; the lymphatics standing out like stiff, red cords; Sigmund's gland and those in the axilla were swollen and painful; his temperature was 102.5°, pulse 110; had severe cephalalgia and was constipated.

No history of injury could be gotten. Diagnosis of cellulitis

[1] Read before the Medical Society of the University of Maryland, December 5, 1893.

and lymphangitis was made. Two incisions in finger and one in dorsum of hand were made by Professor Tiffany. A wet corrosive sublimate dressing, 1 to 5000, was applied. He was given some Rochelle salts and tincture of iron and instructed to report the next day.

July 25. Hand feeling comfortable; had a good night's sleep; temperature 99.2°, pulse 100; owing to the marked improvement the dressing was not removed.

July 26. Hand very painful, had been unable to sleep during the night; the dressing was changed by one of the clinical assistants, who noticed that the hand was more swollen and very tender upon pressure. The hand was re-dressed with wet corrosive sublimate gauze, 1 to 5000.

July 27. At 1 P.M. I was sent for to see the man, who presented the following symptoms:

He complained of great pain in the hand and arm, and was unable to sleep during the night. He had had two chills, one at 3 the other at 5 A.M., which were followed by much sweating; temperature was now 105.5°, pulse 130. Examination of the hand showed it to be much swollen and œdematous; end of third finger was green and without sensation; two small bullæ, which contained a bloody, offensive fluid, were on dorsum of the hand. The incisions which had been made on the 24th were covered with a yellowish green slough; the swelling extended half way up the forearm; the lymphatics in the arm were more marked than before; Sigmund's gland and those in the axilla were also more swollen and painful.

Upon pressure a very distinct and extensive emphysematous crackling could be felt over the dorsum of the hand, extending nearly as high as the wrist-joint.

The diagnosis of acute emphysematous gangrene was made.

The man was informed of the serious nature of his trouble, and that an amputation might be necessary, to which he consented, but which was objected to by his wife. However, the patient was etherized and long free incisions with sterilized instruments were made quite through the emphysematous tissue, going through the deep fascia and exposing the deep structures.

The flexor tendons of the third finger were green and soft as high as the metacarpo-phalangeal articulation. They were excised. His hand was then put into a very hot corrosive sublimate bath, 1 to 1000, and watched; the hot solution was changed every twenty minutes. After the incisions were made and before any antiseptic

substance had come into contact with the wounds six culture tubes were inoculated; three Esmarch gelatin and three stab agar agar, the latter tubes being half full of agar.

The patient reacted very slowly from the anæsthetic, being unconscious for several hours. Three and a half hours later the end of the third finger was cut off with scissors, causing no pain to the patient. Crackling at this time was about the same; temperature 105.2°, pulse 126, and very weak.

About six hours after the operation both the patient and his wife requested an amputation. Everything was gotten in readiness, but upon examination the emphysema had distinctly diminished in extent; temperature was 104°, pulse 110. It was decided not to amputate immediately, but wait and watch the progress of the disease.

12.30 A.M., about nine hours after the incisions were made, the crackling was decidedly less, although the hand was much more swollen. The wounds which I made were covered with a yellowish slough; temperature 103° F., pulse 110; patient passed three ounces of urine, which contained albumin, casts and red blood corpuscles; his hand and arm were kept constantly in the hot corrosive sublimate bath.

July 28, 7.30 A.M. Crackling could now be felt only over quite a small surface on dorsum of hand; other local symptoms were about the same; temperature 102.2°, pulse 105.

10.30 A.M. Professor Tiffany saw the patient with me. He found crackling over small surface on the back of the hand, which was very much swollen and œdematous; lymphangitis not so marked; the hot corrosive sublimate bath was continued.

The crackling was felt for the last time at 12.30 P.M. The patient improved rapidly from that time; his temperature at 8 P.M. was 103°, pulse 105; they never reached such high points afterwards.

The hand and arm were kept constantly in the bichloride bath for five days; the sloughs separated on the third day, leaving large irregular wounds which healed very slowly. On the sixth day the corrosive sublimate bath was discontinued and a bichloride gauze dressing applied. Now, three months having elapsed since his sickness, he still has some albumin and casts in his urine. The wounds have healed, but have left the hand quite stiff; it is, however, gradually getting more motion.

The only medicines which the patient got were whiskey, infus. digitalis, hypodermic strychnine, and, later, iron.

BACTERIOLOGICAL EXAMINATION.

The six culture tubes which were inoculated from the blood that came from the gangrenous tissue at the time when the incisions were made give the following results:

Esmarch Gelatin Cultures.—The gelatin was liquefied and kept fluid at a temperature of 30° C.; a drop of the blood was taken on a sterilized platinum loop and mixed well with the gelatin in one of the tubes; from the first tube the other two tubes were inoculated; they were then rolled on ice and kept at room temperature; as the weather was warm (20° to 23° C.) it was not necessary to put them into a thermostat. There was no visible growth present at the end of twenty-four hours; at the end of forty-eight hours, however, there was an abundant growth in all the tubes; tubes No. 1 and No. 2 being diffusely cloudy, and No. 3 containing small, pale, grayish colonies; no liquefaction. Examination of these gelatin cultures showed them to be pure cultures of the streptococcus pyogenes; no other organism being present. They grew in very long chains, in some instances reaching across several fields of the microscope; as these tubes remained a pure culture of the streptococcus pyogenes, I shall not refer to them again.

Nutrient Agar Agar.—The tubes, as already mentioned, were filled about half full of agar agar and boiled so as to displace the oxygen, which was present in the medium, as it was suspected that an anærobic organism might be present in the tissues. They were inoculated by making a deep stab with a long, straight platinum needle, which was sterilized; it contained a small amount of blood from the wounds. The inoculations were made at just about the time when the agar agar commenced to get hard, so that when the needle was withdrawn the line of puncture would close and thus exclude the oxygen. These cultures were also kept at room temperature, which was warm (20° to 23° C.).

In twenty-four hours they contained a distinct growth along the line of puncture in the lower two-thirds of the culture, no growth being present in the upper one-third; the growth was of a whitish color, and formed of small round colonies, with irregular contours. There were two small gas bubbles present in the lower portion of the culture.

Forty-eight hours. The growth now extended along the entire line of inoculation, coming quite to the surface. The colonies in the lower portion of the tube were much larger and darker, being

quite different from the ones in the upper portion. There were a number of air bubbles throughout the lower third of the culture. They contained a fluid which was opaque.

Microscopical examination of some of the culture from near the surface showed it to consist of streptococci, which were identical with the organisms that were found in the gelatin culture.

One of the tubes was broken on a sterilized dish, and the growth from the lower portion examined under the microscope, which showed it to consist of a bacillus somewhat shorter than the anthrax bacillus, and having slightly rounded ends. It stained deeply with Gentian violet.

Now, seeing that I had a mixed culture present, and that one of the organisms was probably an anærobic bacillus, I made two sets of Esmarch agar agar cultures from a portion of the growth in the lower part of the broken tube, also two stab cultures. The cultures were made anærobic, according to the method of Buchner.[1] At the end of twenty-four hours I had quite a distinct growth in all the tubes.

Esmarch Tubes.—Colonies were numerous, small, whitish color, more or less round, with irregular contours and having a dark centre.

Forty-eight hours. Upon examination it was found that two distinct and different kinds of colonies were present, the one being much larger than the other. The smaller colonies were found to be the streptococcus pyogenes, the larger ones the bacillus. The colonies of the bacilli were round with irregular contours, with little projections from all around their edges that gave to them a bristly appearance. They had a dark central spot; the colonies of the two different organisms could be easily identified. I will not describe the streptococci colonies, as there was no difficulty in recognizing the organism.

Stab Cultures.—Twenty-four hours. A distinct growth was present along the entire line of puncture; the growth was of a whitish brown color. Numerous gas bubbles were disseminated through the medium; the bubbles contained an opaque fluid.

Forty-eight hours. Examination of the cultures showed them to be mixed, containing both the bacillus and the streptococcus; these cultures were, therefore, not further used.

Two stab tubes of gelatin and two stab tubes of agar agar were inoculated from the single colonies of the bacillus on the agar agar roll; one tube of each medium contained sugar, the other two being

[1] Centralblatt für Bakteriologie, 1888, Band IV, p. 149.

plain. Two tubes of sugar bouillon were also inoculated at the same time from the same colonies; they were all put into Buchner's jars, except one of the bouillon, which remained exposed to the air. At the end of twenty-four hours all the anærobic cultures contained an abundant growth.

Agar Agar and Gelatin Cultures.—The growth extended along the entire length of the line of puncture, and was of a whitish brown color. The colonies near the surface could be seen to be identical with those from which the inoculation was made; numerous gas bubbles were present throughout the media, they contained an opaque fluid; also an opaque fluid accumulated on the surface of the culture; the growth was more pronounced in the tubes that contained the sugar than in the others.

Forty-eight hours. Growth much more marked. In the agar agar tube that contained sugar; the medium was split into two parts and separated about one-eighth of an inch; in the crack a cloudy fluid had accumulated. In the gelatin tube the growth seemed to sink to the bottom along the line of inoculation, due to a softening, although the gelatin was not liquefied; there were more gas bubbles in the gelatin than in the agar agar tubes.

Anærobic Bouillon Culture.—Twenty-four hours. The bouillon was quite opaque, having small particles suspended and a thick whitish sediment. The surface was covered with a foam, showing that considerable gas formation was taking place in the tube.

Forty-eight hours. The culture by this time had become clear, having a thick whitish sediment that was quite tenacious; there was not quite so much foam on the surface as the day before. The bouillon culture that was exposed to the air remained clear, having no growth.

Microscopical examination of the anærobic bouillon culture showed it to be a pure culture of a long bacillus, which stained very easily with gentian violet and methylene blue. Some of the organisms were not uniformly stained, but had a granular appearance. The bacillus was a little shorter than the anthrax bacillus; it did not grow in chains, was mostly single or in irregular clumps, but sometimes two or more were joined together, end to end. The bacillus was usually straight, although some were bent, resembling somewhat the tubercle bacillus; the ends were not cut square, but slightly rounded; no spores were observed in any of the organisms; spore stains were used, but with negative results.

There could be seen a clear zone surrounding most of the

bacilli, which was demonstrated to be a thick capsule by treating the organism with strong acetic acid, and replacing the acid with an aqueous solution of gentian violet, after the method of Welch. Drop cultures showed it to be non-motile. The bacillus was strictly anærobic, not growing in the presence of oxygen and a non-liquefier of gelatin.

REMARKS.

The bacillus that was isolated from the above case is identical in all particulars with the bacillus ærogenes capsulatus of Welch and Nuttall,[1] who first discovered it in the blood and tissues of a man who died from the rupture of a large thoracic aneurism; extensive emphysema was found all through the blood and tissues a few hours after death. The formation of gas was so extensive that large bubbles were present in the veins; when these bubbles of gas were lighted they would burn with a slight explosion, showing they were not atmospheric air.

Cover-slip preparations of the blood and tissues were examined which showed the presence of large numbers of bacilli that subsequently proved to be the cause of the emphysema. Cultures were made and studied which correspond exactly with those that I have described.

Inoculation experiments on rabbits showed that large doses could be injected into the circulation without any severe symptoms following; but if the animal was killed shortly after the inoculation, rapid and extensive emphysema would develop throughout the tissue. In no instance did the growth take place before the death of the animal. One pregnant rabbit, however, died, and developed rapid post-mortem emphysema.

At the time when Professor Welch discovered the bacillus ærogenes capsulatus I was working in his laboratory, under his personal supervision, and did special work with the organism at that time, and had frequent opportunities in assisting him in his experiments, which training enabled me to identify the bacillus ærogencs capsulatus with certainty.

Eugene Frænkel[2] reported later several fatal cases of

[1] Bulletin, Johns Hopkins Hospital, Vol. III, p. 81.

[2] Centralblatt f. Bakteriologie, Band XIII, p. 1.

emphysematous phlegmons which followed hypodermic needle punctures. He made a bacteriological examination and found a bacillus which he called bacillus phlegmonis emphysematosa, which is identical with the bacillus ærogenes capsulatus of Welch and Nuttall. P. Ernst[1] and Graham, Steward and Baldwin[2] have recently reported the presence of the same bacillus in cases of abortion with rapid post-mortem development of gas in the blood-vessels.

These few cases are sufficient to prove that under some favorable circumstances the bacillus may grow in the living tissues, and cause death by a rapid progressive septicæmia.

The case which I report proves that the bacillus ærogenes capsulatus may develop locally in the tissues during life and in association with pyogenic cocci produce emphysematous necrotic inflammation, and that recovery may take place without general penetration of gas into the vessels, at least in sufficient amount to be demonstrable.

The case shows several interesting things, viz., that the bacillus does grow in the living body, causing great destruction both locally and constitutionally, the infection remaining local and ending in recovery without the removal of the diseased part. Such cases are, however, extremely rare, usually ending in death regardless of what measures are taken. It also carries out the suggestion of Frænkel that sometimes life may be saved without an amputation. The most favorable cases for such treatment are those where the gangrene starts in a finger or a toe. In these cases the surgeon has time to wait a short while, and amputate if the disease advances. It is the only thing that can be tried in cases where the trouble starts in the trunk.

Knowing that the bacillus which causes the disease cannot live in the presence of oxygen, Frænkel suggested that the parts be freely incised so as to admit the access of air to the diseased tissue, and at the same time apply some oxidizing agents as permanganate of potash or $H_2 O_2$, etc. In my case I depended upon the powerful antiseptic properties of corrosive sublimate with the most happy result.

[1] Virchow's Archiv, Band CXXXIII, p. 308.

[2] Columbus Medical Journal, August, 1893.

In concluding, I beg to call attention to the fact that the patient was found to have albumin casts and blood in his urine a few hours after the operation, which are also in his urine at the present time. This strongly suggests that the patient had some organic changes in his kidneys before the time of his infection, which may have predisposed him to this disease.

From the fact that he had a mixed infection of the streptococcus pyogenes and the bacillus ærogenes capsulatus, it is impossible to say to what extent the disease was due to one or the other of the organisms.

The formation of the gas must be entirely due to the bacillus. The mixed infection may also have been the cause of the disease remaining local, as the growth of one of the organisms may have prevented the growth of the other to a certain extent and thus localized the trouble.

Perhaps it might be well to say here that the bacillus of malignant œdema is quite different and distinct from the bacillus ærogenes capsulatus.

The bacillus of malignant œdema was first discovered by Pasteur[1] among his "septicémie," and described as "vibron septique."

Several years later Koch[2] found the same bacillus in the human body, and called it the bacillus of malignant œdema. See also Gaffky.[3]

The bacillus of malignant œdema is widely distributed throughout nature, being found quite often in garden earth, and also in dead animal bodies, where putrefaction with the formation of gas is present, and in emphysematous gangrene.

Clinically, I do not think a differential diagnosis can be made between an infection with the bacillus of malignant œdema and the bacillus ærogenes capsulatus without a bacteriological examination, as the pathological lesions are quite the same in both infections; the general symptoms in both are those of a profound, rapid, progressive septic poisoning.

All the cases that are reported, due to infection with the

[1] Bull. de l'Acad. de Méd., 1877–1881.
[2] Mitth. aus dem Ges-Amt., I, s. 54.
[3] Ibid, s. 88.

bacillus ærogenes capsulatus, have died. The true nature of the infection was recognized post-mortem.

The case which is reported in this paper is the only recorded one that ended in recovery and the nature of the infection ascertained during life.

The symptoms in the above case were in no way distinguishable from those of malignant œdema infection. The differential diagnosis can, however, always be made by a carefully conducted bacteriological examination.

I place in parallel columns the characteristics and differences between the two bacilli, thus showing at a glance they are quite unlike:

Bacillus of Malignant Œdema.	Bacillus Ærogenes Capsulatus.
Grouping. Often in pairs, joined together end to end, also often in long chains.	*Grouping.* Single or in irregular clumps, seldom in chains of more than three or four.
Mobility. Very motile.	*Mobility.* Absolutely non-motile.
Spore Formation. Rapid development of large spores.	*Spore Formation.* No spores.
Behavior in Gelatin. Rapid and extensive liquefaction.	*Behavior in Gelatin.* No liquefaction, only a slight softening.
Staining. Special staining shows many large spores.	*Staining.* Special staining shows no spores.
Capsule. Demonstrable.	*Capsule.* Very distinct and thick.
Pathogenesis. Inoculation experiments on animals always cause death a few hours to a day or so.	*Pathogenesis.* Inoculation experiments on animals are often negative, often no growth takes place before the animal has been killed from some other cause, after which rapid post-mortem development takes place. (See Welch's experiments, Bulletin Johns Hopkins Hospital.)